APPENDIX C

ESU Descriptions

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1.0 ESU DESCRIPTION AND STATUS

Life history, species status and factors for decline specific to each of the 14 ESUs (five species) affected by the 4(d) limit are described below. Factors for decline are related to land use practices, water development projects, inadequacy of existing regulatory mechanisms, fisheries, hatcheries and other uses of artificial production. Land use is further described in subsection 4.2, Land Use Categories. More detailed information about each of the species and ESUs discussed below can be found in NMFS' status reviews of west coast salmon species (Busby et al. 1996; Gustafson et al. 1997; Johnson et al. 1997; Myers et al. 1998).

1.1 Chinook Salmon ESU

Chinook salmon, also known by the common names king, spring, quinnalt, and tyee salmon, historically ranged from the Ventura River in California to Point Hope, Alaska in North America (Healey 1991). Additionally, chinook salmon have been reported in the Mackenzie River area of northern Canada (McPhail and Lindsey 1970). Many of the chinook salmon stocks in these ESUs have been in decline for decades (Myers et al. 1998). Factors implicated in the decline of the species include dams; logging; agriculture; water withdrawal; mining; and urbanization, all of which contribute to habitat loss and degradation, overfishing; and the wide use of hatcheries and other forms of artificial propagation (Myers et al. 1998). In addition, sources suggest that the "inadequacy of existing regulatory mechanisms" is a general reason for overall decline in abundance of chinook salmon (Oregon Natural Resources Council and Nawa 1995).

Of the Pacific salmon, chinook salmon is the largest of the salmon species in body size and exhibits one of the most diverse and complex life history strategies. Healey (1986) described 16 age categories for chinook salmon, 7 total ages with 3 possible freshwater ages. Two generalized freshwater life-history types were initially described by Gilbert (1912): "stream-type" chinook salmon reside in freshwater for a year or more following emergence, whereas "ocean-type" chinook salmon migrate to the ocean within their first year. Healey (1983, 1991) has promoted the use of broader definitions for "ocean-type" and "stream-type" to describe two distinct races of chinook salmon. This racial approach incorporates life history traits, geographic distribution, and genetic differentiation and provides a valuable frame of reference for comparisons of chinook salmon populations.

Chinook may spend one to six years in the ocean before returning to their natal streams to spawn (Figure C-1). Most of the salmon in these 14 ESUs mature as three to five year old adults (Myers et al. 1998).

Figure C-1. Marine range of West Coast chinook salmon (sources: PFMC 1999 and Myers et al. 1996).

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Ocean distribution differs between ocean- and stream-type chinook (Healey 1983, 1991). Ocean-type chinook tend to migrate along the coast, and stream-type chinook migrate far from the coast in the central North Pacific. Chinook populations south of Cape Blanco tend to migrate to the south, while those north of Cape Blanco tend to migrate in a northerly direction (Myers et al. 1998). Chinook populations within the ESUs discussed here can be characterized by their time of freshwater entry as spring, summer, or fall runs. Spring chinook tend to enter freshwater and migrate far upriver, where they hold and become sexually mature before spawning in the late summer and early autumn. Fall chinook enter freshwater in a more advanced stage of sexual maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of their natal rivers and spawn within a few days or weeks of freshwater entry (Fulton 1968, Healey 1991). Summer chinook are intermediate between spring and fall runs, spawning in large and medium-sized tributaries, and not showing the extensive delay in maturation exhibited by spring chinook (Fulton 1968).

There are three chinook ESUs included in the 4(d) limits: Puget Sound ESU, Lower Columbia River ESU, and Upper Willamette River ESU (Figures C-2, C-3, C-4). These ESUs were listed as threatened on March 24, 1999 (64 FR 14308), and critical habitat was designated for these ESUs on February 16, 2000 (65 FR 7764).

1.1.1 Puget Sound Chinook Salmon

The Puget Sound chinook salmon ESU encompasses all naturally spawned spring-, summer- and fall-runs of chinook salmon in the Puget Sound region from the North Fork Nooksack River to the Elwha River on the Olympic Peninsula (Figure C-2). Critical habitat includes all marine, estuarine, and river reaches accessible to listed chinook in Puget Sound in South Puget Sound, Hood Canal, and North Puget Sound to the international boundary at the outer extent of the Strait of Georgia, Haro Strait, and the Strait of Juan de Fuca, below naturally occurring barriers (65 FR 7764). Major river basins containing spawning and rearing habitat for this ESU comprise approximately 13,761 square miles in Washington. This ESU is located in portions of Clallam, Island, King, Kitsap, Jefferson, Mason, Pierce, San Juan, Skagit, Snohomish, and Whatcom Counties in Washington (NMFS 2002a).

WDF et al. (1993) identified 28 stocks in Puget Sound, distributed among five geographic regions. NMFS is currently engaged in delineating the population structure of this and other ESUs as an initial step in a formal recovery planning effort that is now underway. Although these determinations have not been finalized at this time, the Puget Sound Technical Recovery Team has tentatively identified 21 independent populations within the ESU (PSTRT 2001). Historically more prevalent in Puget Sound, currently spring chinook populations are found in the Dungeness, North and South Fork Nooksack, Skagit and White Rivers (Nehlsen et al. 1991, WDF et al. 1993, PSTRT 2001). Summer chinook populations are found in the Upper Skagit, Lower Sauk, Stillaguamish, and Snohomish Rivers. Fall chinook are found throughout the major river basins of

Figure C-2. Puget Sound Chinook Salmon ESU.

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Figure C-3. Lower Columbia River Chinook Salmon ESU.

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Figure C-4. Upper Willamette River Chinook Salmon ESU.

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Puget Sound (WDF et al. 1993, PSTRT 2001). Chinook salmon (and their progeny) from the following hatchery stocks are considered essential to the recovery of the listed ESU: Kendall Creek (spring run); North Fork Stillaguamish River (summer run); White River (spring run); Dungeness River (spring run); and Elwha River (fall run) (64 FR 14308).

Chinook salmon in this area predominantly exhibit an ocean-type life history including coastal ocean migration patterns. Although some spring chinook populations in the Puget Sound ESU have a high proportion of two year old juvenile salmon, most populations emigrate as one year olds (Myers et al. 1998). Puget Sound chinook mature from two to six years of age, primarily returning as three and four year old adults (Myers et al. 1998; WDFW/PSTT 2001). Adult spring chinook typically return to freshwater in April and May, spawning in August and September (Orrell 1976, WDF et al. 1993). Adult summer chinook typically begin their return in June and July, spawning in September. Adult summer/fall and fall chinook begin their return spawning migration in August and spawn from late September through January (WDF et al. 1993).

Overall abundance of chinook salmon in this ESU has declined substantially from historical levels, and many populations are small enough that genetic and demographic risks are likely to be relatively high. In its 1998 status review, NMFS noted the average potential run size (hatchery + natural) at that time was approximately 240,000 and natural spawning escapements averaged 25,000 (Myers et al. 1998). Since that review, natural spawning escapement has averaged approximately 31,000. Although long- and short-term trends for populations in North Puget Sound have been predominately negative, several stocks have shown improvements in escapements in recent years. Both long- and short-term trends for populations in the South Puget Sound and Hood Canal regions are predominantly positive, however, the contribution of hatchery fish to natural escapements in these regions may be substantial, masking the trends in natural production. Spring-run chinook salmon populations throughout this ESU are depressed (Myers et al. 1998).

Freshwater habitat throughout the range of the ESU has been blocked or degraded, with upper tributaries widely affected by poor forestry practices and lower tributaries and mainstem rivers affected by agriculture and urbanization. At the time of its status review, NMFS expressed concern that harvest rates of natural stocks in mixed-stock fishing activities might be excessive, as evidenced by declines in escapements of most stocks managed for natural escapement despite curtailed terminal fishing activities (Myers et al. 1998). However, other data indicates that overall abundance for these stocks also declined possibly as a result of habitat degradation combined with poor ocean conditions. Increased escapements observed in recent years may be the result of improved ocean survival and harvest management measures implemented in the mid-1990s.

There is concern that the preponderance of hatchery production throughout the ESU may mask trends in natural populations and make it difficult to determine whether they are self-sustaining.

The widespread use of a limited number of hatchery stocks may have resulted in increased risk of loss of fitness and diversity among populations (Myers et al. 1998).

1.1.2 Lower Columbia River Chinook Salmon ESU

The Lower Columbia River chinook salmon ESU includes all natural-origin populations residing below impassable natural barriers form the mouth of the Columbia River to the crest of the Cascade Range just east of Hood River in Oregon and the White Salmon River in Washington (65 FR 7764) (Figure C-3). The historic site of Celilo Falls on the Columbia River, east of the Hood River in Oregon is considered the eastern boundary of this ESU since it may have been a migrational barrier to chinook at certain times of the year (Myers et al. 1998). Critical habitat includes all river reaches accessible to listed chinook in Columbia River tributaries between the Grays and White Salmon Rivers in Washington and the Hood and Willamette Rivers in Oregon and downstream to the mouth of the Columbia River, excluding some dams or naturally impassable barriers (65 FR 7764). This ESU is located in portions of Clark, Cowlitz, Skamania, and Wakiakum Counties in Washington; and in portions of Clatsop, Columbia, Multnomah, Hood River, and Clackamas Counties in Oregon. The Cowlitz, Kalama, Lewis, Washougal, and White Salmon Rivers constitute the major systems in Washington; the lower Willamette, Hood, and Sandy Rivers are the major systems in Oregon (NMFS 2002). Major river basins containing spawning and rearing habitat for this ESU comprise approximately 6,338 square miles in Oregon and Washington (NMFS 2002b).

The ESU does not include spring populations above Willamette Falls, stream-type spring chinook salmon found in the Klickitat River (which are considered part of the Mid-Columbia River spring ESU), or the introduced Carson spring chinook salmon strain. Tule fall chinook salmon in the Wind and Little White Salmon Rivers are included in this ESU, but not introduced upriver bright fall chinook salmon populations in the Wind and White Salmon Rivers (Myers et al. 1998). Of the fourteen hatchery stocks included in the ESU, one was considered essential for recovery (Cowlitz River spring chinook) but was not listed (64 FR14329). WDF et al. (1993) identified 20 stocks within the ESU, but surveyed only Washington stocks that did not include the Clackamas tule, Sandy spring, or Sandy bright spawning aggregations in Oregon. NMFS is currently engaged in delineating the population structure of this and other ESUs as an initial step in a formal recovery planning effort that is now underway.

There are three different runs of chinook salmon in the LCR ESU: spring-run, late fall brights, and early fall tules. Spring-run chinook salmon in the lower Columbia River, have a stream-type juvenile life history and enter freshwater as adults in March and April, well in advance of spawning in August and September. Historically, fish migrations were synchronized with periods of high rainfall or snow melt to provide access to upper reaches of most tributaries where spring stocks would hold until spawning (Fulton 1968; Olsen et al. 1992; WDF et al. 1993). The tule and bright fall chinook exhibit an ocean-type live history and northerly ocean migration patterns, with bright fish tending to travel father north than the tule stocks. Tule fall chinook begin entering the Columbia River in August, rapidly moving into the lower Columbia River tributaries to begin spawning in September and October. Bright fall chinook enter the Columbia River over a longer period of time beginning in August and do not begin spawning until October with spawning observed into the following March in some locations. All lower Columbia River chinook mature from two to six years of age, primarily returning as three and four year old adults (Myers et al. 1998).

Estimated overall abundance of chinook salmon in this ESU is not cause for immediate concern. Long-term trends in fall run escapement are mixed, with most larger stocks positive, while the spring run trends are positive or stable. Short-term trends for both runs are more negative, some severely so (Myers et al. 1998). However, apart from the relatively large and apparently healthy fall-run population in the Lewis River, production in this ESU appears to be predominantly hatchery-driven with few identifiable native, naturally reproducing populations. About half of the populations comprising this ESU are very small, increasing the likelihood that risks due to genetic and demographic processes in small populations will be important.

Spring chinook were present historically in the Sandy, Clackamas[1], Cowlitz, Kalama, Hood, and Lewis Rivers. Spawning and juvenile rearing areas have been eliminated or greatly reduced by dam construction on all these rivers. The native Lewis run became extinct soon after completion of Merwin Dam in 1932. The natural Hood River spring chinook population was extirpated in the 1960s after a flood caused by the natural breaching of a glacial dam resulted in extensive habitat damage in the West Fork production areas. Currently non-listed hatchery spring chinook from the Deschutes River ate being released into the Hood River as part of a reintroduction program. The remaining spring chinook stocks in the Lower Columbia River ESU are found in the Sandy, Lewis, Cowlitz, and Kalama Rivers. Numbers of naturally spawning spring-run chinook salmon are very low, and have historically had or continue to have significant contributions of hatchery fish. Recent escapements above Marmot Dam on the Sandy River average 2,800 and have been increasing (ODFW 1998a). Hatchery-origin spring chinook are no longer released above Marmot Dam; the proportion of first generation hatchery fish in the escapement is relatively low, on the order of 10 to 20 percent in recent years. Recent average escapement of naturally spawning spring chinook adults in the Cowlitz, Kalama, and Lewis Rivers are 237, 198, and 364, respectively (LeFleur 2000, 2001). The amount of natural production resulting from these escapements is unknown, but is presumably small since the remaining habitat in the lower rivers is not the preferred habitat for spring chinook (ODFW 1998a). Hatchery escapement goals have been consistently met in the Cowlitz and Lewis Rivers. In the past, when necessary, brood stock from the Lewis was used to meet production goals in the Kalama. Although the status of hatchery stocks are not always a concern or priority from an ESA perspective, in situations where the historic spawning habitat is no longer accessible, the status of the hatchery stocks is pertinent.

[1] Clackamas River spring chinook are considered part of the listed Upper Willamette River chinook ESU.

Fall chinook populations in the Lower Columbia River are self sustaining, and escapements are generally stable (ODFW 1998a). The tule component of the fall chinook populations spawn in the Coweeman, East Fork Lewis, and Clackamas Rivers. Escapements for these populations have averaged several hundred to 1,000 per year (NMFS, 2000). Some natural spawning of tule fall chinook occurs in other areas but is thought to result primarily from hatchery-origin strays. Tule fall chinook are produced from the Elochoman, Cowlitz, Toutle, Kalama, Spring Creek, and Washougal hatcheries in Washington and Big Creek hatchery in Oregon. The bright component of Lower Columbia River fall chinook spawn in the North Fork Lewis, Sandy, and East Fork Lewis Rivers. Lower Columbia River bright stocks are among the few healthy natural chinook stocks in the Columbia River Basin. Escapement to the North Fork Lewis River has exceeded its escapement goal of 5,700 by a substantial margin every year since 1980, except 1999, with a recent five year average escapement of 8,400. Escapements of the two smaller populations of brights in the Sandy and East Fork Lewis River have been stable for the last 10 to 12 years and are largely unaffected by hatchery fish (NMFS 2001a; ODFW 1998a).

Freshwater habitat is in poor condition in many basins, with problems related to forestry practices, urbanization, and agriculture. Dam construction on the Cowlitz, Lewis, White Salmon, and Sandy Rivers has eliminated access to a substantial portion of the spring-run spawning habitat, with a lesser impact on fall-run habitat (Myers et al. 1998).

The large numbers of hatchery fish in this ESU make it difficult to determine the proportion of naturally produced fish. In spite of the heavy impact of hatcheries, genetic and life-history characteristics of populations in this ESU still differ from those in other ESUs. However, the potential loss of fitness and diversity resulting from the introgression of hatchery fish within the ESU is an important concern. In response to concerns about straying into tributaries of the Lower Columbia (Myers et al. 1998), the release locations for non-ESU Rogue River bright fall-run fish in Youngs Bay were changed and as a result, stray rates have declined markedly (NMFS 2000b).

1.1.3 Upper Willamette River Chinook Salmon ESU

The Upper Willamette River chinook salmon ESU includes native spring populations in the Willamette River and tributaries upstream of Willamette Falls, including naturally produced spring-run fish in the Clackamas River (Figure C-4). Critical habitat includes all river reaches accessible to listed chinook in the Clackamas and Willamette Rivers and their tributaries above Willamette Falls and downstream to the mouth of the Columbia River, excluding some dams or naturally impassable barriers (65 FR 7764). The ESU is located in portions of Benton, Clackamas, Lane, Linn, Marion, Polk, Yamhill, and Washington Counties in Oregon. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 8,575 square miles (NMFS 2002c).

Historically, there were five major basins that produced spring chinook including the Clackamas, North and South Santiam Rivers, McKenzie, and the Middle Fork Willamette. Dams on the South Fork Santiam and Middle Fork Willamette eliminated wild spring chinook in those systems (ODFW 1998b). Although there is still some natural spawning in these systems below the dams, habitat quality is such that there is probably little resulting production, and the spawners are likely of hatchery origin. Populations in several smaller tributaries that also used to support spring chinook are believed to be extinct (Nicholas 1995). The McKenzie, Clackamas, and North Santiam are therefore the primary basins that continue to support natural production. Of these, the McKenzie is considered the most important. Prior to construction of major dams on Willamette tributaries, the McKenzie produced 40 percent of the spring chinook above Willamette Falls and it may now account for half the production potential in the Basin. NMFS is currently engaged in delineating the population structure of this and other ESUs as an initial step in a formal recovery planning effort that is now underway. Although five Willamette River spring-run hatchery stocks were included in the ESU, none were considered essential for recovery (64 FR14329).

Upper Willamette River chinook are one of the most genetically distinct groups of chinook in the Columbia River Basin. This may be related in part to the narrow time window available for passage above Willamette Falls. Upper Willamette spring chinook salmon populations exhibit features of both the ocean-type and stream life history types. Their far northerly ocean migration pattern into British Columbia and Alaska is more consistent with an ocean-type life history. The available information indicates juveniles emigrate predominantly as two year old juvenile salmon, however, most of the data are from returning hatchery adults and may not accurately reflect the pattern of natural fish. Adults mature from three to five years of age, primarily returning as four and five year olds (Myers et al. 1998). Spring chinook from the Willamette River have the earliest return timing of chinook stocks in the Columbia Basin with freshwater entry beginning in February. Historically, spawning occurred between mid-July and late October. However, the current spawn timing of hatchery and wild chinook in September and early October is likely due to hatchery fish introgression.

The abundance of naturally-produced spring chinook in the ESU has declined substantially from historic levels. Historic escapement levels may have been as high as 200,000 fish per year (Myers et al. 1998). Total abundance has been relatively stable at approximately 20,000 to 30,000 fish. From 1946 to 1950, the geometric mean of Willamette Falls counts for spring chinook was 31,000 fish , which represented primarily naturally-produced fish. The most recent five year average total escapement above the falls was 32,500 fish, but comprised predominantly of hatchery-produced fish (NMFS 2001a). Current natural escapement is less than 5,000 fish, and about two-thirds of the natural spawners are estimated to be first-generation hatchery fish. This suggests that the natural population is falling far short of replacing itself even in the absence of fisheries (Myers et al. 1998).

Although natural escapements are substantially depressed, the number of naturally spawning fish has gradually increased in recent years (NMFS 2001a). The number of natural-origin fish crossing Leaburg Dam has increased steadily from 800 in 1994 to about 1,400 in 1999 and 2,000 in 2000, compared with the interim escapement goal of 3,000 to 5,000 (ODFW 1998b). Most of the natural spawning on the Clackamas River occurs above the North Fork Dam with 900 to 2,200 adults crossing the dam in recent years, compared with an interim escapement goal of 2,900 adults (ODFW 1998b). Over 70 percent of the production capacity of the North Santiam system was blocked by the Detroit Dam. There are no passage facilities at the Dam so all of the current natural production potential remains downstream. There were 194 redds counted in this area in 1998, 221 in 1999 and 345 in 2000, compared to an average of 140 in 1996 and 1997 (ODFW/WDFW 2000; ODFW 2001).

The primary cause of decline of chinook salmon in this ESU is the blockage of access to large areas of spawning and rearing habitat by dam construction. The remaining habitat has been degraded by thermal effects of dams, forestry practices, agriculture, and urbanization. Another concern for this ESU is that commercial and recreational harvest were high, relative to the apparent productivity of natural populations (Myers et al. 1998). In 2001, Oregon began requiring release of all wild fish from its terminal area recreational fisheries (identified by an unclipped adipose fin). These new regulations are expected to reduce harvest mortality by 70 percent from historic levels. Substantial efforts have been taken to remedy some of the past hatchery practices including limiting the proportion of hatchery spawners in some natural production areas, and reincorporating local-origin wild fish into the hatchery broodstock (ODFW 1998b).

1.2 Coho Salmon

Coho salmon are historically widespread, occurring in most major river basins around the Pacific Rim. In North America, coho are found from Monterey Bay, California to Point Hope, Alaska (Lichatowich 1999) (Figure C-5). West coast coho salmon populations have declined to small fractions of their historic levels, and continuing declines and local extinctions are widespread within this range. Different sources provide differing estimates for risk of extinction for the coho salmon, but all concur that populations have substantially declined as compared to historical levels. For example, Frissell (1993) estimated that coho salmon are extinct in the eastern half of their range in the lower 48 states and imperiled throughout the southern two-thirds of this range. The decline of coho salmon populations has been attributed primarily to habitat destruction. Other factors for decline include overfishing, artificial propagation, and poor ocean conditions (Weitkamp et al. 1995).

Coho salmon exhibit variable life history patterns within and between populations including, such traits as body size and shape, spawning frequency, and egg size. Land use, fisheries, and the influence of hatchery fish may affect these traits. In general, most coho south of central British Columbia mature at three years of age, spending 1.5 years in freshwater and 1.5 years in the

Figure C-5. Marine range of West Coast coho salmon (sources: PFMS 1999 and Myers et al. 1996).

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ocean before spawning (Weitkamp et al. 1995). With little overlap between generations, separate brood lineages are at high risk from the effects of catastrophic events such as floods or de-watering events. An exception to this are jacks, sexually mature males that return to freshwater to spawn after only 5 to 7 months in the ocean (Weitkamp et al. 1995).

Most west coast coho enter rivers in October and spawn from November to December and occasionally into January. The time between river entry and spawning differs among regions. Central California coho spend little time between river entry and spawning while northern stocks may spend one or two months in freshwater before spawning and river entry may occur over several months (Flint and Zillges 1980; Fraser et al. 1983; Leidy and Leidy 1984). In general, earlier migrating fish spawn farther upstream within a basin than later migrating fish, which enter rivers in a more advanced state of maturity (Sandercock 1991). Coho fry emerge the following March to May, and peak outmigration generally occurs about a year later (Sandercock 1991).

One coho salmon ESU is encompassed in the 4(d) limits: the Oregon Coast ESU. The Oregon Coast ESU was listed as threatened species on August 10, 1998 (63 FR 42587). The U.S. District Court in Eugene, Oregon set aside this listing on September 12, 2001 pending a review of the treatment of hatchery fish in the original listing determination. The listing was re-instated by the Ninth Circuit court, but continues to be under review.

1.2.1 Oregon Coast Coho Salmon

The Oregon Coast Coho ESU includes naturally spawning coho originating from coastal streams south of the Columbia River and north of Cape Blanco, Oregon (Figure C-6). Critical habitat includes all river reaches and estuarine areas accessible to listed coho in this area, excluding some dams or naturally impassable barriers (65 FR 7764). Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,604 square miles in Oregon. The following Oregon counties lie partially or wholly within these basins (or contain migration habitat for the species): Benton, Clatsop, Columbia, Coos, Curry, Douglas, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill (NMFS 2000d).

Although coho production in this ESU is spread over a large number of basins, currently most of the production is in the southern portion of the ESU. The Oregon Department of Fish and Wildlife divided the Oregon Coastal coho ESU into three Gene Conservation Areas (GCA) based on studies of genetic variation and life history traits (Kostow 1995). The Mid-North Coast GCA encompasses coho in basins from the Necanicum River south to the Siuslaw River. The Umpqua GCA includes the entire Umpqua Basin. The Mid-South Coast GCA covers the Siltcoos and Tahkenitich Lake Basins north of the mouth of the Umpqua, and continues south of the Umpqua to the northern tip of Cape Blanco at Sixes River (Jacobs *et al.* 2000). Subsequently, the Mid-North Coast GCA was further subdivided into North and North-Central management unit, and the Umpqua GCA was combined with the adjacent Mid-South Coast GCA for fisheries management

Figure C-6. Oregon Coast Coho Salmon ESU.

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purposes (PFMC 1999). Of the nine hatchery populations included in the ESU, none are considered essential to recovery (63 FR42587).

Oregon Coastal coho generally migrate to sea in the May after their first year in freshwater, moving northerly along the coast as far north as the Gulf of Alaska (Sandercock 1991). The majority of tagged adult coho are recovered off the coasts of Oregon and California with smaller numbers found off the coasts of Washington and British Columbia. After spending another year or 18 months at sea, adults migrate south, entering freshwater in September and October. Peak spawning occurs from mid-November into early January depending on the population (Weitkamp et al. 1995).

Based on historic commercial landing statistics and estimated exploitation rates, coho salmon escapement to coastal Oregon rivers has been estimated at between 1 and 1.4 million fish in the early 1900s, with harvest of nearly 400,000 fish (Mullen 1981; Lichatowich 1989). Current abundance of coho salmon on the Oregon coast may be less than 5 percent of that in the early part of this century. The Oregon Department of Fish and Wildlife (1995) presented estimates of coho salmon abundance at several points in time from 1900 to the present. These data show a decline of about 75 percent from 1900 to the 1950s, and a further decline of about 90 percent since the 1950s. The majority of this decline occurred in the early 1970s, and spawner counts have remained relatively stable since that time. Escapement from 1994 to 1998 has been estimated at an annual average of about 34,000 adults (Jacobs et al. 2000). Among the GCAs, abundance has been lowest in the North Coast group and highest in the Mid-South GCA. During the 1994-1998 period, escapement for the North Coast, Mid Coast, Umpqual and Mid-South GCAs averaged about 3,100, 9,000, 7,200 and 14,600, respectively. Pre-harvest abundance has declined, however, and spawner-to-spawner return ratios have been below replacement in many years, in spite of very substantial reductions in harvest. Average recruits-per-spawner may also be declining (Weitkamp et al. 1995). This decline has been associated with a reduction in habitat capacity of nearly 50% (Lichatowich 1989). Current production potential for coho salmon in coastal Oregon rivers has been estimated at about 800,000 fish using stock-recruit models (Lichatowich 1989). Estimates on the proportion of hatchery fish in a sample of rivers and lakes show a wide range from less than 10 percent hatchery fish in lake samples to more than 75 percent in two rivers.

The extensive presence of hatchery-origin adults spawning in several coastal rivers is a cause for concern about the sustainability of natural production in these systems. In recent years, the number of juvenile coho salmon released from Oregon Coast hatcheries has been substantially reduced in response to ESA listings of coho stocks. Widespread habitat degradation resulting from road building, resource extraction, water diversion, and withdrawal and urbanization activities, has also been noted as a factor of decline (Weitkamp et al. 1995; 62 FR 24592).

1.3 Sockeye Salmon

Historically, sockeye salmon were found in North America from the Kuskokwim River in Alaska, south to the Rogue River in Oregon[2] (Gustafson *et al.* 1997). Today, there are no recognized sockeye populations in coastal Oregon rivers or in California. Dam construction reduced or eliminated passage to spawning grounds for populations in the Columbia River and Snake River Basins, and in Puget Sound. Bristol Bay in Alaska and the Fraser River in British Columbia dominate sockeye production in North America.

Sockeye salmon exhibit a greater variety of life history patterns than other Pacific salmonids, with the exception of steelhead and cutthroat trout. Healey (1986, 1987) identified 22 different combinations of freshwater and marine ages for males, and 14 different age compositions for females depending on life history strategy. Sockeye exhibit two general life history and three freshwater rearing strategies and spawn in a wide variety of habitats from lake beaches to rivers (Gustafson et al. 1997). Anadromous sockeye migrate to sea after rearing in freshwater while the non-anadromous form, or kokanee, do not migrate and become resident in their lake environment (Burgner 1991). Some offspring of anadromous parents may become residual and are called residuals or resident sockeye (Ricker 1938). Lake-type sockeye rear in lakes for one to three years before migrating to sea. River-type sockeye spend one or two years in their natal river before migrating to sea, and sea-type sockeye spend a few months to two years in their natal river before migrating to sea (Gilbert 1918; Foerster 1968; Wood 1995). River and sea-type sockeye populations are often found in areas near or influenced by glaciers and may stray more frequently than lake-type sockeye (Wood 1995). All anadromous forms return to freshwater to spawn after one to four years of ocean residence. The different life history forms appear to be influenced by environmental stability and ease of access to spawning and rearing areas (Gustafson et al. 1997). The majority of sockeye spawn in lakes or in streams near lakes, with juveniles spending one to three years in the lake before ocean migration (Gustafson et al. 1997).

For North American populations, juveniles may spend a month or more in estuary areas close by their rivers of origin, before migrating north along the outer coast to the Gulf of Alaska and west into the open ocean. Peak catches of juvenile sockeye are observed in the Gulf of Alaska in August and by September they are moving along the Aleutian Islands toward the open ocean (Burgner 1991). Sockeye generally mature at three to eight years of age, although most return as three to five year olds (Gustafson et al. 1997). Both river entry and spawn timing show a high degree of variability. River entry occurs anywhere from January through September, with spawning occurring anywhere from late September into February depending on the population.

One sockeye salmon ESU is included in the 4(d) limits: the Ozette Lake ESU, listed as threatened on March 25, 1999 (64 FR 14528). Critical habitat for this ESU was designated on

[2] Anecdotal reports indicate sockeye may have occurred as far south as northern California.

February 16, 2000 (65 FR 7764). Snake River sockeye were listed as endangered in 1991 (56 FR 58619).

1.3.1 Ozette Lake Sockeye Salmon

The Ozette Lake sockeye salmon ESU includes all sockeye salmon that return to Ozette Lake through the Ozette River and currently spawn primarily in lakeshore upwelling areas on Ozette Lake (Figure C-7). A small proportion of this ESU may also spawn below the lake in the Ozette River and its tributary, Coal Creek. If "kokanee-sized" *O. nerka* observed spawning with sockeye salmon in Ozette Lake are identified as residual or resident sockeye salmon, then they are to be considered as part of the Ozette Lake sockeye salmon ESU (Gustafson et al. 1997). Critical habitat includes all lake areas and river reaches accessible to listed sockeye in Lake Ozette, excluding some dams or naturally impassable barriers (65 FR 7764). Lake Ozette is within Clallam County on the Olympic Peninsula in Washington. Watersheds containing spawning and rearing habitat for this ESU comprise approximately 88 square miles in Washington (NMFS 2002e).

Currently, spawning is restricted to submerged beaches where upwelling occurs along the lakeshore or to tributary outwash fans (Dlugokenski et al. 1981, WDF et al. 1993), primarily at Olsen's Beach and Allen's Bay. These spawning aggregations are currently considered a single population based on genetic analysis (NMFS 2002f). Historically, sockeye may also have spawned in tributary creeks of Ozette Lake including Big River, Umbrella Creek and Crooked Creek and in the Ozette River (Dlugokenski et al. 1981; WDF et al. 1993; Jacobs et al. 1996) but do not presently spawn there. Although the Umbrella Creek hatchery sockeye population is included in the ESU, it is not considered essential to recovery (64 FR14528)

Figure C-7. Ozette Lake Sockeye Salmon ESU.

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Adults return to spawn from three to five years of age, although most return as four year olds (NMFS 2002f). Ozette Lake sockeye generally spend about two of those years in the North Pacific (Figure C-8). In general, Ozette Lake sockeye enter the Ozette Lake system from April to early August (WDF et al. 1993) or from May to August (Dlugokenski et al. 1981). LaRiviere (1991) found that high summer water temperatures and low flows may control the length of entry timing by creating a thermal block to migration at some point in mid-summer. The majority of spawners at both lake beaches and in the tributaries begin spawning by late-October to early-November and are generally spawned out by late-November to early December (NMFS 2002f), although spawning has been reported to extend into January and February in some years (Dlugokenski et al. 1981). Fry rear in the lake for a year before migrating to sea as smolts. Ozette Lake smolts are unusually large, the third largest sockeye salmon smolt reported in the literature (Dlugokenski et al. 1981).

The historical abundance of Ozette Lake sockeye is poorly documented, but is believed to have declined significantly from historic levels. Historical estimates indicate run sizes of a few thousand sockeye salmon (Kemmerich 1945; Rounsefell and Kelez 1938), with a peak recorded harvest of nearly 18,000 in 1949 (WDF 1974). Abundance in the 1977-1995 period was estimated to have decreased by an average of 3 percent per year, increasing to 10 percent per year in 1986-1995. At the time of NMFS' status review, escapement for this ESU averaged about 700 adults (1992-1996) (Gustafson et al. 1997). Recent run size estimates and analysis of previous estimation methods indicate that sockeye abundance within the ESU may be relatively stable or increasing. The most recent four year annual mean run size was 1,598 adults (range=1,133 to 2,076). Recent analyses indicate the total annual Ozette Lake sockeye salmon abundance (based on adult run size data presented in Jacobs et al. 1996) has increased at 2 percent per year on average for the most recent 10 years (1989 to 1998) compared with a declining trend in abundance of -2.0 percent per year on average from 1977 through 1998 (NMFS 1998). Some of this increase is attributable to the hatchery supplementation and recovery program initiated in response to the decline in population abundance.

Several studies have concluded that a combination of factors likely contributed to the decline of this ESU including introduced species, predation, loss of tributary populations, decline in quality of beach-spawning habitat, unfavorable oceanic conditions, excessive historical harvests, introduced diseases, and the potential genetic effects of past and on-going hatchery practices (Dlugokenski et al. 1981; Beauchamp et al. 1995; Jacobs et al. 1996). Habitat degradation in the form of sedimentation, stream-bed scouring, increased flows, and degraded water quality have been primarily attributed to logging and associated road building (Blum 1988). No directed fishery has occurred on this stock since 1982 (WDF et al. 1993).

Figure C-8. Marine range West Coast sockeye salmon (sources: Gustafson et al. 1997 and Myers et al. 1996).

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1.4 Chum Salmon

Historically, chum salmon were distributed throughout the coastal regions of western Canada and the United States, as far south as Monterey Bay, California. Presently, major spawning populations are found only as far south as Tillamook Bay on the northern Oregon coast (Johnson *et al.* 1997). Also known as dog salmon, chum salmon are the second largest Pacific salmonid in body size after chinook and may have also been the most abundant salmonid. It is estimated that prior to the 1940s, chum accounted for almost 50 percent of the total Pacific Ocean salmonid biomass.

Chum salmon spend more of their life history in marine waters than other Pacific salmonids. Chum spend two to five years in the northeast Pacific Ocean feeding areas prior to migrating southward during the summer months as maturing adults along the coasts of Alaska and British Columbia in returning to their natal streams (PNPT/WDFW 2000) (Figure C-9). Most chum mature as four year old adults (Johnson et al. 1997). Chum salmon usually spawn in the lower reaches of rivers, with redds usually dug in the mainstem or in side channels of rivers from just above tidal influence to nearly 100 km from the sea. Juveniles outmigrate to salt water almost immediately after emerging from the gravel that covers their redds (Salo 1991). This ocean-type migratory behavior contrasts with the stream-type behavior of some other species in the genus Oncorhynchus (e.g., coastal cutthroat trout, steelhead, coho salmon, and most types of chinook and sockeye salmon), which usually migrate to sea at a larger size, after months or years of freshwater rearing. This means that survival and growth in juvenile chum salmon depend less on freshwater conditions (unlike stream-type salmonids that depend heavily on freshwater habitats) than on favorable estuarine conditions. Another behavioral difference between chum salmon and species that rear extensively in freshwater is that chum salmon form schools, presumably to reduce predation (Pitcher 1986), especially if their movements are synchronized to swamp predators (Miller and Brannon 1982).

There are two chum ESUs included in the 4(d) limit: Hood Canal ESU and Columbia River ESU, which were listed as threatened on March 25, 1999 (64 FR 14508). Critical habitat for this ESU was designated on February 16, 2000 (65 FR 7764).

Figure C-9. Marine range of West Coast chum salmon based on an extremely limited dataset (source: Myers et al. 1996).

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1.4.1 Hood Canal Chum Salmon

The Hood Canal summer-run chum ESU includes summer-run chum salmon populations in Hood Canal and in Discovery and Sequim Bays on the Strait of Juan de Fuca (Figure C-10). The ESU also includes summer-run chum salmon in the Dungeness River, but their status is uncertain (PNPT/WDFW 2000). Critical habitat includes all estuarine areas, river reaches, and tributaries accessible to listed chum salmon draining into Hood Canal as well as Olympic Peninsula Rivers, and those marine areas between and including Hood Canal and Dungeness Bay, excluding some dams or areas above longstanding impassable barriers (65 FR7764). The Hood Canal summer-run chum salmon ESU falls within portions of Clallam, Jefferson, Kitsap and Mason Counties in Washington (NMFS 2002g).

Hood Canal summer chum are distinguishable from other Puget Sound chum by an early return and spawning timing that creates a temporal separation from fall chum stocks spawning in the same rivers. This allows reproductive isolation between summer and fall stocks (WDF et al. 1993). The ESU has two geographically distinct regions: the Strait of Juan de Fuca and Hood Canal. Although the populations all share similar life history traits, the summer chum populations in the two regions are affected by different environmental and harvest impacts and display varying survival patterns and stock status trends. Of the 16 populations of summer chum identified in this ESU, seven are considered to be “functionally extinct”. The remaining nine populations are well distributed throughout the ESU except for the eastern side of Hood Canal, which were historically among the least productive in the ESU (PNPT/WDFW 2000). In the Hood Canal region, summer chum are still found in the Dosewallips, Duckabush, Hamma Hamma, Lilliwaup, Big and Little Quilcene, and Union Rivers. A few chum have been observed in other systems during the summer chum migration period, but these observations are sporadic and are thought to be strays from other areas. In the Strait of Juan de Fuca, summer chum stocks are found in Snow, Salmon, Jimmycomelately Creeks and the Dungeness River.

Hood Canal summer chum use the estuarine and marine areas in Hood Canal and the Strait of Juan de Fuca for rearing and seaward migration as juveniles. Summer chum mature primarily at three and four years of age, with low numbers returning at ages two and five. Little is known about the details of the ocean migration and distribution of salmon from this ESU. Some data suggest that Puget Sound chum, including those in the Hood Canal summer-run chum ESU, may not make an extended migration into northern British Columbian and Alaskan waters, but instead may travel directly offshore into the north Pacific Ocean (Hartt and Dell 1986). In general, maturing chum salmon in the North Pacific begin to enter coastal waters from June to November. Adults delay migration in extreme terminal marine areas for up to several weeks before entering the streams to spawn. Hood Canal summer chum enter freshwater from early August through mid-October and spawn from late August through mid-October (WDF et al. 1993; PNPT/WDFW 2000). Spawning occurs in the lower 1 to 2 miles of each summer chum stream. This characteristic may reflect an adaptation to low flows present during their late summer/early fall spawning ground migration timing, which confines spawning to areas with sufficient water

Figure C-10. Hood Canal Summer-Run Chum Salmon ESU.

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volume. However, this spawning pattern also makes the incubating eggs more vulnerable to scour during periods of high flows (PNPT/WDFW 2000).

Although abundance was high in the late 1970s, abundance for most Hood Canal summer chum populations declined rapidly beginning in 1979, and has remained at depressed levels. The terminal run size for the Hood Canal summer chum stocks averaged 28,971 during the 1974 to 1978 period, declining to an average of 4,132 during 1979 to 1993. Abundance during the 1995 to 2000 period improved, averaging 8,724 adults. However, much of the increase in abundance can be attributed to a supplementation program for the Big/Little Quilcene River summer chum stock begun in 1992. Escapements in the Union River have been stable or increasing relative to historical levels. Escapements to the Dosewallip and Duckabush Rivers have been generally above threshold levels of concern, but are highly variable. Escapements in the Hamma Hamma and particularly the Lilliwaup have been below threshold escapement levels often in recent years. The terminal abundance of summer chum in the Strait of Juan de Fuca region began to decline in 1989, a decade after the decline observed for summer chum in Hood Canal. Terminal abundance declined from an average of 1,923 for the 1974 to 1988 period to a average of 477 during 1989 to 1994 period. During the most recent five year period (1995 to 2000) the average for the region increased to 758 adults. However, much of the increase may be due to the supplementation program in the Snow/Salmon system, initiated in 1992. Escapements in Jimmycomelately have continued to be poor, i.e., less than 100 spawners in 1998, 1999 and 2000 (NMFS 2001b). In 2001, escapement was 300 adults, substantially up from previous years (NMFS 2002).

The causes of decline for the Hood Canal summer-run chum ESU have been attributed to a combination of high fishery exploitation rates, shifts in climatic conditions that have changed patterns and intensity of precipitation, and the cumulative effects of habitat degradation, especially for those systems in the Strait of Juan de Fuca region of the ESU (PNPT/WDFW 2000; Johnson *et al.* 1997). Channel, riparian forest and sub-estuarine conditions were moderately to severely degraded in all the watersheds due to a history of logging, road building, rural development, agriculture, water withdrawal, and channel manipulations throughout the ESU (PNPT/WDFW 2000). Total exploitation rates have dropped dramatically since 1995 as a result of fishery actions taken to protect summer chum and other salmonid species.

Supplementation programs were instituted beginning in 1992 due to assessments of moderate or high risk of extinction for several stocks (PNPT/WDFW 2000). These programs are scheduled to end in 12 years, unless re-evaluation at that time indicates extending them would be beneficial to recovery of the ESU.

1.4.2 Columbia River Chum Salmon

This ESU includes all naturally produced chum salmon populations that enter the Columbia River (Figure C-11). Critical habitat includes all estuarine areas, tributaries and river reaches accessible to listed chum salmon in the Columbia River downstream from Bonneville Dam, excluding Oregon tributaries upstream of Milton Creek and areas above some dams or naturally impassable barriers (65 FR7764). The Columbia River chum salmon ESU is falls within portions of Clark, Cowlitz, Lewis, and Wahkiakum Counties in Washington and Clatsop, Columbia, and Multnomah Counties in Oregon (NMFS 2002h).

Historically, chum salmon were abundant in the lower reaches of the Columbia River and may have spawned as far upstream as the Walla Walla River (Johnson et al. 1997). However, reductions in available habitat currently limit chum salmon in the Columbia River to tributaries below Bonneville Dam. Presently only two chum salmon populations are recognized and monitored in the Columbia River (Grays River, and Hardy and Hamilton Creeks/Ives Island group), although chum have been reported in other areas (Salo 1991; Kostow 1995).

The information on ocean migration patterns and distribution is limited, and no region-specific information for this ESU is available (Johnson et al. 1997). There is some speculation that Columbia River chum had a more southerly ocean distribution similar to the present-day distribution and migration pattern of Columbia River coho (Sandercock 1991). Grays River chum salmon enter the Columbia River from mid-October to mid-November, but do not reach the Grays River until late October to early December. These fish spawn from early November to late December. Fish returning to Hamilton and Hardy Creeks begin to appear in the Columbia River earlier than Grays River fish (late September to late October) and have a more protracted spawn timing (mid-November to mid-January). At present, only a single hatchery produces chum for the Columbia River, and it is not considered part of the ESU or essential for recovery.

Current abundance is less than 1percent of historic levels, and the ESU has lost some of its original genetic diversity. The estimated minimum run size for the Columbia River chum salmon ESU has been relatively stable, since the run collapsed during the mid-1950s (Johnson et al. 1997). Information from stream surveys of the remaining populations suggests that there may be a few thousand chum spawning annually in the Columbia River basin (Johnson et al. 1997).

Decline of this ESU is attributed to dams and habitat degradation primarily due to diking and wetland loss (Sherwood et al. 1990, Johnson et al. 1997). Hatchery fish have had little influence on the wild component of the Columbia River chum salmon ESU (Johnson et al. 1997).

Figure C-11. Columbia River Chum Salmon ESU.

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1.5 Steelhead

Steelhead in North America are distributed from Northwestern Mexico to the Kuskokwim River in Alaska (Lichatowich 1999). Steelhead exhibit more complex life history traits than other Pacific salmonid species. Some forms of steelhead are anadromous; while others, called rainbow or redband trout, reside permanently in freshwater. Anadromous steelhead reside in freshwater for as long as seven years before moving to the ocean. Steelhead typically reside in marine waters for two to three years before returning to their natal stream to spawn at four or five years of age. Some Oregon and California populations include "half-pounders" that migrate from the ocean to freshwater and return to the ocean without spawning (Busby et al. 1996).

Steelhead trout can be divided into two basic run types based on the level of sexual maturity at the time of river entry and the duration of the spawning migration (Burgner et al. 1992). The stream-maturing type (inland), or summer steelhead, enters freshwater in a sexually immature condition and requires several months in freshwater to mature and spawn. The ocean-maturing type (coastal), or winter steelhead, enters freshwater with well-developed gonads and spawns shortly after river entry (Barnhart 1986). Variations in migration timing exist between populations. Both summer and winter steelhead occur in British Columbia, Washington, and Oregon; Idaho has only summer steelhead; California is thought to have only winter steelhead (Busby et al. 1996). In the Pacific Northwest, summer steelhead enter freshwater between May and October, and winter steelhead enter freshwater between November and April.

Steelhead are iteroparous, or capable of spawning more than once before death. Steelhead spawn in cool, clear streams with suitable gravel size, depth, and current velocity. Intermittent streams may also be used for spawning (Barnhart 1986; Everest 1973). Steelhead enter streams and arrive at spawning grounds weeks or even months before they spawn and are vulnerable to disturbance and predation. Cover, in the form of overhanging vegetation, undercut banks, submerged vegetation, submerged objects such as logs and rocks, floating debris, deep water, turbulence, and turbidity is required to reduce disturbance and predation of spawning steelhead. Summer steelhead usually spawn farther upstream than winter steelhead (Withler 1966). Juveniles typically rear in freshwater from one to four years before migrating to the ocean. Winter steelhead generally smolt after two years in freshwater (Busby et al. 1996). Steelhead typically reside in marine waters for two or three years before returning to their natal stream to spawn at four or five years of age.

Based on catch data, juvenile steelhead tend to migrate directly offshore during their first summer, rather than migrating nearer to the coast as do salmon. During fall and winter, juveniles move southward and eastward (Hartt and Dell 1986). Available fin-mark and coded-wire tag data suggests that winter steelhead tend to migrate farther offshore but not as far north into the Gulf of Alaska as summer steelhead (Burgner et al. 1992) and that southern Oregon and California populations are south-migrating rather than north-migrating (Nicholas and Hankin 1988; Pearcy et al. 1990; Pearcy 1992) (Figure C-12). Ocean distribution data for specific ESUs is limited.

Figure C-12. Marine range of West Coast steelhead (sources: INPFC Bulletin Number 51 and Myers et al. 1996).

CLICK HERE TO OPEN FIGURE

Maturing Columbia River steelhead are found off the coast of Northern British Columbia and west into the North Pacific Ocean (Myers et al 1996). At the time adults are entering freshwater, tagging data indicate that immature Columbia River steelhead are out in the mid-North Pacific Ocean. Even less is known about the marine distribution patterns of California steelhead. However, marine distribution might be inferred from the distribution of available tagging data by general life history type and from the commonalities in distribution of other salmonids from the region. No tag recoveries of mature California steelhead have been found in the North Pacific Ocean or northern inland waters. A few immature California steelhead were recovered during the 1956 to 1995 time period in the open ocean, consistent with the winter-run life history (Myers et al. 1996). Tags from California coho and chinook are recovered almost exclusively in California and Oregon fisheries. Since California coho and chinook stocks share similar patterns of ocean distribution, it is reasonable to assume that listed California steelhead ESUs would also have a southerly distribution.

The 4(d) Rule includes two inland steelhead ESUs (Middle Columbia River ESU and Snake River Basin ESU) and five coastal steelhead ESUs (Lower Columbia River, Central California Coast, South-Central California Coast, California Central Valley, and Upper Willamette).

1.5.1 Upper Willamette Steelhead ESU

The Upper Willamette River steelhead trout ESU includes all naturally produced steelhead in the Willamette River and its tributaries upstream of Willamette Falls (Figure C-13). Critical habitat is designated to include all river reaches accessible to listed steelhead in the Willamette River and its tributaries above Willamette Falls upstream to, and including, the Calapooia River (65 FR7764). Also included are adjacent riparian zones, as well as river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to, and including, the Willamette River in Oregon. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 4,872 square miles in Oregon. The following counties lie partially or wholly within these basins (or contain migration habitat for the species): Clark, Cowlitz, Pacific, and Wahkiakum Counties in Washington; Benton, Clackamas, Clatsop, Columbia, Lincoln, Linn, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill Counties in Oregon (NMFS 2002i). The ESU was listed as threatened on March 25, 1999 (64 FR 14517).

Five major basins historically produced winter steelhead including the Mollala, North Santiam, South Santiam, Calapooia, and West Valley Rivers (i.,e., Luckiamute, Rickreal, Yamhill, Tualatin); the largest remaining population is in the Santiam River system. However, smaller populations exist in the Molalla, Calapooia, and Tualatin River systems. The North Santiam River hatchery stock is part of this ESU, but NMFS determined that it was not essential for recovery, and, therefore, listing was not warranted (64 FR 14525). Steelhead in the Upper Willamette

Figure C-13. Upper Willamette River Steelhead ESU.

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River basin were heavily influenced by hatchery practices and introductions of non-native stocks, as well as introductions of native fish into new areas (NMFS 2000). To date, all releases of hatchery winter steelhead have been eliminated in the ESU, and there are no plans to reinitiate hatchery production in the foreseeable future (ODFW 2001). Only hatchery summer steelhead releases still occur in the Upper Willamette River and these are limited to areas where returning adults can be collected and removed from the population before they can spawn naturally.

The Upper Willamette River ESU is a late-migrating winter group, rearing two years in freshwater and two years in the Pacific Ocean (Busby et al. 1996) before returning to spawn. Freshwater entry is primarily during March and April (Howell et al. 1985). This unusual run timing appears to be an adaptation from ascending Willamette Falls, which function as an isolating mechanism for upper Willamette River steelhead.

No estimates of abundance prior to the 1960s are available. Abundance has been declining steeply since the late 1980s going from an average of over 15,000 in the 1970s and 1980s to several thousand today (Busby et al. 1996). The main production of native (late-run) winter steelhead is in the North Fork Santiam River where escapement has averaged 2,000 steelhead in recent years. In the mid-1990s, estimates of hatchery contribution to natural spawning in the North Fork Santiam ranged from 14 percent to 54 percent (Busby et al. 1996). In recent years however, the proportion of potential spawners that are of hatchery origin has continued to decline as hatchery winter steelhead are no longer released into the Upper Willamette River.

The potential negative influence of hatchery fish through genetic effects and competition between native and non-native stocks was noted as the primary factor of concern for this ESU (Busby et al. 1996). Habitat blockage from dams and habitat degradation from logging and urbanization have contributed to stream flow and temperature problems and loss of riparian habitat (Bottom et al. 1985, Busby et al. 1996).

1.5.2 Lower Columbia River Steelhead ESU

The Lower Columbia River steelhead ESU includes all naturally produced steelhead in tributaries to the Columbia River between the Cowlitz and Wind Rivers in Washington and the Willamette and Hood Rivers in Oregon, excluding steelhead in the upper Willamette River above Willamette Falls (Upper Willamette ESU) and steelhead in the Little and Big White Salmon Rivers in Washington (Middle Columbia ESU) (Busby et al. 1996)(Figure C-14). Critical habitat is designated to include all river reaches accessible to listed steelhead in Columbia River tributaries between the Cowlitz and Wind Rivers in Washington and the Willamette and Hood Rivers in Oregon, inclusive. Also included are adjacent riparian zones, as well as river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to the Hood River in Oregon (65 FR7764). Major river

Figure C-14. Lower Columbia River Steelhead ESU.

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basins containing spawning and rearing habitat for this ESU comprise approximately 5,017 square miles in Oregon and Washington. The following counties lie partially or wholly within these basins (or contain migration habitat for the species): Clackamas, Clatsop, Columbia, Hood River, Marion, Multnomah, and Washington; Washington Counties in Oregon Clark, Cowlitz, Lewis, Pacific, Skamania, and Wahkiakum Counties in Washington (NMFS 2002j). This ESU was listed as a threatened species on March 19, 1998 (63 FR13347).

Steelhead in this ESU belong to the coastal genetic group (Schreck et al. 1986, Reisenbichler et al. 1992, Chapman et al. 1994) and include both winter steelhead(Cowlitz, Toutle, Coweeman, Kalama, Washougal, Sandy, Hood, and Clackamas ,and Wind Rivers) and summer steelhead (Kalama, Lewis, Hood, and Washougal Rivers). WDF et al. (1993) identified 19 stocks considered to be predominantly of natural production. Among hatchery stocks, late-spawning Cowlitz River Trout Hatchery and the late-spawning Clackamas River hatchery stock are part of the ESU, but are not considered essential for recovery (NMFS 2000). Hatchery programs using local natural stocks of winter steelhead have been developed in the Sandy, Kalama, and Hood River basins.

Life history attributes for steelhead within this ESU appear to be similar to those of other west coast steelhead. Most Lower Columbia River steelhead rear two years in freshwater and spend one or two years in the ocean prior to re-entering fresh water, where they may remain up to a year prior to spawning (Howell et al. 1985; BPA 1992). Summer-run stocks generally enter freshwater from May through October while winter stocks generally enter freshwater from November to May (Busby et al 1996). Peak entry generally occurs in July (B. Leland to S. Bishop, pers. comm. 7/99).

No estimates of historical abundance (pre-1960s) specific to this ESU are available. A conservative estimate of current abundance puts the average run size at greater than 16,000. Abundance trends are mixed and possibly affected by short-term climate conditions. At the time of NMFS' status review, the majority of stocks for which data are available within this ESU were declining, although some had increased strongly. The strongest upward trends were those of either non-native stocks (Lower Willamette River and Clackamas River summer steelhead) or stocks recovering from major habitat disruption and still at low abundance (mainstem and North Fork Toutle River) (Busby et al. 1996). Since 1996 when the status review was completed, listed Lower Columbia River steelhead populations have generally increased, with some populations rebounding more quickly than others.

The magnitude of hatchery production, habitat blockages from dams, and habitat degradation from logging and urbanization are areas of concern. The widespread production of hatchery steelhead within this ESU (hatchery contribution in some areas over 50 percent) creates specific concerns for summer steelhead and Oregon winter steelhead stocks, where there appears to be substantial overlap in spawning between hatchery and natural fish (Busby et al. 1996). Most of the hatchery stocks originate from stocks within the ESU, but many are not native to local river basins. Because of their limited distribution in upper tributaries and the urbanization surrounding the lower tributaries (e.g., the lower Willamette, Clackamas, and Sandy Rivers run through Portland, Oregon, or its suburbs), summer steelhead appear to be more at risk from habitat degradation than winter steelhead.

1.5.3 Middle Columbia River Steelhead

This ESU includes all naturally produced steelhead in the Columbia River Basin upstream of the Wind River in Washington and the Hood River in Oregon (exclusive) to the Yakima River in Washington, except for steelhead in the Snake River Basin (Busby et al. 1996)(Figure C-15). Critical habitat is designated to include all river reaches accessible to listed steelhead in Columbia River tributaries (except the Snake River) between Mosier Creek in Oregon and the Yakima River in Washington (inclusive) (65 FR7764). Also included are adjacent riparian zones, as well as river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to the Yakima River in Washington. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 26,739 square miles in Washington and Oregon. The following counties lie partially or wholly within these basins (or contain migration habitat for the species): Benton, Clark, Columbia, Cowlitz, Franklin, Kittitas, Klickitat, Pacific, Skamania, Wahkiakum, Walla Walla, and Yakima Counties in Washington; Clatsop, Columbia, Crook, Gilliam, Grant, Harney, Hood River, Jefferson, Morrow, Multnomah, Sherman, Umatilla, Union, Wallowa, Wasco, and Wheeler Counties in Oregon; (NMFS 2002k). The ESU was listed as a threatened species on March 25, 1999 (64 FR 14517).

The Middle Columbia River steelhead ESU includes the only populations of winter inland steelhead in the United States (in the Klickitat River, Washington, and Fifteenmile Creek, Oregon). WDFW et al. (1993) identified six stocks within the ESU, four of which are considered to have predominantly natural production[3]. Within the ESU, the Klickitat River is unusual in that it produces both summer and winter steelhead. Both the Deschutes River and Umatilla River hatchery stocks are included in the ESU, but are not listed (NMFS 2000).

Most Middle Columbia River steelhead rear two years in freshwater and spend one or two years in the ocean prior to re-entering fresh water, where they may remain up to a year prior to spawning (Howell et al. 1985; BPA 1992). The summer-run stocks generally enter freshwater from May through October (Busby et al. 1996) with peak entry occurring in July (B. Leland to S. Bishop, pers. comm. 7/99). Non-anadromous steelhead co-occur with the anadromous form within this ESU and may not be reproductively isolated from one another (Busby et al. 1996).

[3] The WDF et al. survey addressed only Washington stocks.

Figure C-15. Middle Columbia River Steelhead ESU.

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Historical abundance in the ESU may have been in excess of 300,000 (Busby et al. 1996). Total abundance was estimated at about 200,000 by the early 1980s, and by the early 1990s average abundance was 142,000 with 39,000 naturally produced. Total steelhead abundance in the ESU appears to have been increasing recently, and the naturally produced component has been relatively stable. However, the majority of natural stocks for which there are data within this ESU have been declining, including those in the John Day River, which is the largest producer of wild, natural steelhead. Total run size for the John Day River is probably in excess of 5,000 fish (Busby et al. 1996).

There is particular concern about Yakima River and winter steelhead stocks. Winter steelhead are reported within this ESU only in the Klickitat River and Fifteenmile Creek. No abundance information exists for winter steelhead in the Klickitat River, but winter steelhead are reported to have been declining in abundance in Fifteenmile Creek. Escapement trends for natural summer and winter steelhead have been increasing over the last few years but are still below historic levels.

There is widespread production of hatchery steelhead within this ESU, but it is largely based on within-basin stocks. The estimated proportion of hatchery fish on spawning grounds ranges from low in the Yakima, Walla Walla, and John Day Rivers, to moderate in the Umatilla and Deschutes Rivers. Stream flow, temperature problems, and loss of riparian vegetation has been attributed to grazing and water diversions throughout the ESU (Busby et al. 1996).

1.5.4 Snake River Basin Steelhead

The Snake River Basin steelhead ESU includes all naturally produced steelhead in the Snake River Basin of southeast Washington, northeast Oregon, and Idaho (Busby et al. 1996) (Figure C-16). Critical habitat is designated to include all river reaches accessible to listed steelhead in these areas. Also included are river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to the confluence with the Snake River (65 FR7764). Major river basins containing spawning and rearing habitat for this ESU comprise approximately 29,282 square miles in Washington, Oregon, and Idaho. The following counties lie partially or wholly within these basins (or contain migration habitat for the species): Asotin, Benton, Clark, Columbia, Cowlitz, Franklin, Garfield, Gilliam, Klickitat, Skamania, Wahkiakum, Walla Walla, and Whitman Counties in Washington; Adams, Blaine, Boise, Clearwater, Custer, Idaho, Latah, Lemhi, Lewis, Nez Perce, and Valley Counties in Idaho; Baker, Clatsop, Columbia, Hood River, Morrow, Multnomah, Sherman, Umatilla, Union, Wallowa, and Wasco Counties in Oregon (NMFS 2002l). The ESU was listed as threatened on August 18, 1997 (62 FR 43937).

Figure C-16. Snake River Basin Steelhead ESU.

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This ESU is the most inland group of the West Coast steelhead and consists solely of summer steelhead. WDF et al. (1993) identified three stocks within the ESU[4], all of which were considered depressed. Populations in this ESU are classified into two groups, A- and B-run, based on migration timing, ocean age, and adult size. A-run steelhead occur throughout the Snake River Basin, while B-run steelhead occur only in the Clearwater, Middle Fork Salmon, and South Fork Salmon Rivers (Busby et al. 1996). The Dworshak National Fish Hatchery, Imnaha River, and Oxbow Hatchery populations are included in the ESU, but are not considered essential for recovery and are, therefore, not listed (62 FR 43937).

Snake River Basin steelhead spawning areas are well isolated from other populations and include the highest elevations for spawning (up to 2,000 meters) as well as the longest migration distance from the ocean (up to 1,500 km). Snake River steelhead enter freshwater from June to October and spawn during the following spring from March to May. A-run steelhead are thought to be predominately age-1 ocean, while B-run steelhead are thought to be age-2 ocean (Busby et al. 1996). Both runs usually smolt as two to three year olds (Whitt 1954; BPA 199; Hassemer 1992).

No estimates of abundance prior to the 1960s are available, and current estimates are extremely limited. Escapements above Lower Granite Dam were estimated to be about 71,000 in the early 1990s, with 9,400 of natural origin (7,000 A-run and 2,400 B-run). While total (hatchery and natural) run size has increased since the mid-1970s, there has been a severe recent decline in natural run size. Abundance for the majority of natural stocks for which there are available data has been declining. Parr densities in natural production areas have been substantially below estimated capacity in recent years. Downward trends and low parr densities indicate a particularly severe problem for B-run steelhead, the loss of which would substantially reduce life history diversity within this ESU (Busby et al. 1996).

Interactions between hatchery and wild stocks and the degradation of freshwater habitats within the region (particularly grazing, irrigation diversions, and hydroelectric dams) have all been noted as factors of concern (Busby et al. 1996). Estimates of the proportion of hatchery fish in spawning escapement for Snake River tributaries range from zero percent in Joseph Creek to above 80 percent in the upper Salmon River (Busby et al. 1996). Dams have blocked or otherwise significantly modified the migration corridor in the mainstem Snake and Columbia Rivers, and habitat degradation from other sources has resulted in significant temperature and flow fluctuations, sedimentation, and loss of riparian vegetation.

[4] Ibid.

1.5.5 Central California Coast Steelhead

The Central California Coast steelhead ESU includes all naturally spawning steelhead from the Russian River to Soquel Creek, Santa Cruz County (inclusive), and the drainages of San Francisco and San Pablo Bays, excluding the Sacramento-San Joaquin Basin of the California Central Valley (Central Valley ESU)(Busby et al. 1996)(Figure C-17). Critical habitat is designated to include all river reaches and estuarine areas accessible to listed steelhead in coastal river basins from the Russian River to Aptos Creek, California (inclusive), and the drainages of San Francisco and San Pablo Bays. Also included are all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay from San Pablo Bay to the Golden Gate Bridge (65 FR7764). Major river basins containing spawning and rearing habitat for this ESU comprise approximately 6,516 square miles in California. Alameda, Contra Costa, Marin, Mendocino, Napa, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano, and Sonoma Counties lie partially or wholly within these basins (or contain migration habitat for the species) (NMFS 2002m). This ESU was listed as a threatened species on August 18, 1997 (62 FR43937).

This area includes more than 40 watersheds supporting winter-run steelhead. The largest drainage within the Central California Coast ESU is the Russian River system with approximately 1,000 stream miles of steelhead habitat. The Napa and San Lorenzo Rivers are the other significant drainages with approximately 105 and 85 stream miles of steelhead habitat, respectively. However, most of the streams within the ESU have less than 20 miles of steelhead habitat, individually (CDFG 2001a). This ESU also includes the Big Creek and San Lorenzo River hatchery stocks but they are not listed ((62 FR43937).

The southernmost portion of the range of this ESU (south of Scott and Waddell Creeks, including one of two major rivers within the ESU) and the portion within San Francisco and San Pablo Bays, appears to be at extreme risk (Busby et al. 1996). In the northern coastal portion of the ESU, steelhead abundance in the Russian River has been reduced roughly sevenfold since the mid-1960s, but abundance in smaller streams appears to be stable at low levels. In the mid-1960s, California Department of Fish and Game (CDFG) estimated 94,000 steelhead spawning in many rivers of this ESU. However, this estimate should be viewed with caution given the large amount of uncertainty around the data and estimation methods available at the time (pers. comm. J. Nelson, CDFG to C. Heberer, NMFS, March 14, 2002). No recent estimates of total run size for the ESU are available, although abundance in the Russian and San Lorenzo Rivers is estimated to be less than 15 percent of their 1960s abundance.

The primary risk factors are sedimentation and channel restructuring due to floods, resulting in part from poor land management practices, and the potential negative effects of hatchery fish on natural production (Busby et al. 1996). Passage problems occur throughout the ESU, and dewatering due to irrigation and urban water diversions is also a problem. Increased awareness and concern for the health of wild steelhead populations has resulted in revised hatchery practices to minimize impacts on wild populations. Hatchery origin steelhead are not released in

Figure C-17. Central California Coast Steelhead ESU.

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natural production areas, except in areas immediately downstream of the two primary hatchery facilities, and non-anadromous and/or non-endemic salmonids are rarely planted in anadromous stream reaches (CDFG 2001a).

1.5.6 South-Central California Coast Steelhead

The South-Central California Coast steelhead ESU includes all naturally produced steelhead along the California coast from the Pajaro River drainage in the north to the northern boundary of the Santa Maria River drainage in the south (Busby et al. 1996)(Figure C-18). Critical habitat is designated to include all river reaches and estuarine areas accessible to listed steelhead in coastal river basins from the Pajaro River (inclusive) to, but not including, the Santa Maria River, California (65 FR7764). Major river basins containing spawning and rearing habitat for this ESU comprise approximately 7,246 square miles in California. Monterey, San Benito, San Luis Obispo, Santa Clara, and Santa Cruz Counties lie partially or wholly within these basins (or contain migration habitat for the species) (NMFS 2002n). The ESU was listed as a threatened species on August 18, 1997 .(FR).

Mitochondrial DNA data provide evidence for a genetic transition in the vicinity of Monterey Bay, but do not provide a clear picture of population structure (Busby et al. 1996). In all, there are about 30 major watersheds that support or could support steelhead production within the boundaries of the South Central California Coast ESU (CDFG 2001b). The Whale Rock Reservoir hatchery stock is considered part of this ESU (62 FR43937).

All of the South-Central California Coast ESU populations are winter steelhead. Juvenile salmon generally emigrate to the ocean from April through May near the end of their first year of life, while the stream mouths remain open and return after one or two years at sea (Busby et al. 1996; CDFG 2001b). However, timing of juvenile salmon emigration is dictated by rainfall and river flows and, therefore, highly variable from year to year. Adult spawning migrations have historically occurred from as early November through as late as July. However, runs are initiated only after winter rains have opened stream mouths. Later rainfall in recent years may be resulting in a delay in the opening of stream mouths through sand berms (CDFG 2001b). This, combined with earlier dessication of the streams that closes the sand bars more quickly, has resulted in adult migration now occurring primarily in the February through April period. Each individual run has significant variation in the length of juvenile freshwater residency and the length of ocean residency. This life history variation provides substantial protection from the extreme year to year variation in climate along California's central coast (CDFG 2001b).

Historic abundance information is limited. In the mid-1960s, CDFG (1965) estimated 27,500 steelhead spawning in many rivers of the ESU. No recent estimates of total run size for the ESU are available, however, recent estimates are available for five steelhead streams within the ESU that infer a substantial decline for the ESU as a whole over the past 30 to 40 years. Total run

Figure C-18. South Central California Coast Steelhead ESU.

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size for the five streams combined is less than 500 steelhead, compared with a total of 4,750 for the same streams in 1965 (Busby et al. 1996).

The primary risk factors are habitat degradation and the potential negative effects of hatchery fish on natural production (Busby et al. 1996). Passage problems occur throughout the ESU, and dewatering due to irrigation and urban water diversions is also a problem. There was also concern about the genetic effects of widespread stocking of rainbow trout, however, CDFG has now prohibited stocking of rainbow trout in anadromous waters (Busby et al. 1996).

1.5.7 California Central Valley Steelhead

The California Central Valley steelhead ESU includes all naturally produced steelhead in the Sacramento and San Joaquin Rivers and their tributaries (Busby et al. 1996) (Figure C-19). Critical habitat is designated to include all river reaches accessible to listed steelhead in these areas. Also included are river reaches and estuarine areas of the Sacramento-San Joaquin Delta, all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge. Excluded are areas of the San Joaquin River upstream of the Merced River confluence (65 FR 7764). Major river basins containing spawning and rearing habitat for this ESU comprise approximately 13,096 square miles in California of which a relatively small amount is suitable for steelhead rearing and spawning (Busby *et al.* 1996). Alameda, Amador, Butte, Calaveras, Colusa, Contra Costa, Glenn, Marin, Merced, Nevada, Placer, Sacramento, San Francisco, San Joaquin, Shasta, Solano, Sonoma, Stanislaus, Sutter, Tehama, Tuolumne, Yolo, and Yuba Counties lie partially or wholly within these basins (or contain migration habitat for the species)(NMFS 2002n). The ESU was listed as a threatened species on March 19, 1998.

Steelhead have been extirpated from most of their historical range in this region. Only winter steelhead currently occur within this ESU, although summer steelhead populations may have occurred there into the 1940s (CDFG 1995; McEwan and Jackson 1996). Most indigenous natural steelhead production in this ESU occurs in the upper tributaries of the Sacramento River (Antelope, Deer, and Mill Creeks) below Red Bluff Diversion Dam. Fish passing over the Dam are 70 to 90% of hatchery origin (Busby et al. 1996). The American, Feather, and Yuba Rivers, and possibly the upper Sacramento and Mokelumne Rivers also have naturally spawning populations (CDFG 1995). However, most of these areas are thought to have had substantial hatchery contribution to natural spawning (Busby et al. 1996).

The Sacramento and San Joaquin Rivers and their tributaries provide the only anadromous fish migration route to the drainages of the Sierra Nevada and Southern Cascade mountain ranges. Steelhead in this ESU may travel more than 300 km to spawning streams, making their migration

Figure C-19. Central Valley, California Steelhead ESU.

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the longest of any winter-run population. Juvenile salmon generally emigrate to the ocean from April through May near the end of their first year of life and return after one or two years at sea (Busby et al. 1996). River entry occurs July through May, peaking in September and February; spawning begins in late December and can extend into April (McEwan and Jackson 1996). The Coleman National Fish Hatchery and Feather River Hatchery populations are included in this ESU but are not listed (62 FR43937).

Estimated steelhead escapement in this ESU was almost 27,000 in the mid-1960s (CDFG 1965). Current information is limited, but present total run size is probably less than 10,000 fish (Busby et al. 1996). Steelhead escapement above the Red Bluff Diversion Dam on the Sacramento River declined 9 percent per year from 1966 to 1992, and hatchery returns within the basin show substantial declines as well (McEwan and Jackson 1996).

Habitat concerns in this ESU focus on the widespread degradation, destruction, and blockage of freshwater habitats within the region, and the potential results of continuing habitat destruction and water allocation problems. During the first two-thirds of the twentieth century, dam construction and water diversion projects throughout the Central Valley resulted in the loss of over 85 percent of steelhead spawning and rearing habitat in the Sacramento-San Joaquin River system watershed (IEP 1999). There are also strong concerns about the pervasive opportunity for genetic introgression from hatchery stocks within the ESU and about potential ecological interactions between introduced stocks and native stocks (Busby et al. 1996).

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